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Short Communication

Remediation of Heavy Metals
from Soil by Eco Approaches

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Remediation of Heavy Metals from Soil by Eco Approaches

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Abstract

The contamination of soil by anthropogenic activities is of great concern in recent times. There is an urgent demand of reliable and eco-friendly approaches for remediation of this concern. The current techniques for heavy metal remediation from contaminated soil are costly, time consuming, and harmful for the environment. Toxicity of heavy metals can reduce plant growth, and a high level of presence of these heavy metals is a risk factor to human and plant health. Heavy metals neither biodegradable materials nor are created. They occur naturally in the earth crust, and they reach the environment by human activities. Organic compounds can be degraded, but metals cannot degrade, and therefore effective cleanup requires its immobilization to reduce or remove toxicity. Recently, research focuses on cost-effective technologies to clean polluted areas. Vermiremediation and phytoremediation are two such useful techniques. In these eco-friendly techniques of remediation, the target plants accumulate, volatilize the contaminants, or convert them into some nontoxic forms, thus remediating the soil.

Keywords: Heavy metals; Toxicity; Techniques of phytoremediation; Vermiremediation.

1. INTRODUCTION

Heavy metals neither are biodegradable materials nor are created. They occur naturally in the earth crust, and they reach the environment by human activities [1]. Heavy metals have an atomic mass that is greater than 20, and they are lanthanides, actinides, and metalloids. They are also poisonous or toxic at low concentrations and high in atomic number or density. Heavy metals include cadmium (Cd), lead (Pb), zinc (Zn), mercury (Hg), arsenic (As), chromium (Cr), silver (Ag), copper (Cu), iron (Fe), and the platinum group elements. The main causes behind heavy metal toxicity in the environment are smelters, mining industries, foundries, coal-burning power plants, and agriculture [2].

Bioremediation includes removal of contaminants from the environment by using microorganisms and plants. This method is easy and eco-friendly, and it generates less quantity of secondary wastes as compared to traditional methods. The heavy metal remediation by microorganisms involves use of enzymes such as oxidoreductases and oxygenases enzyme morphological [3].

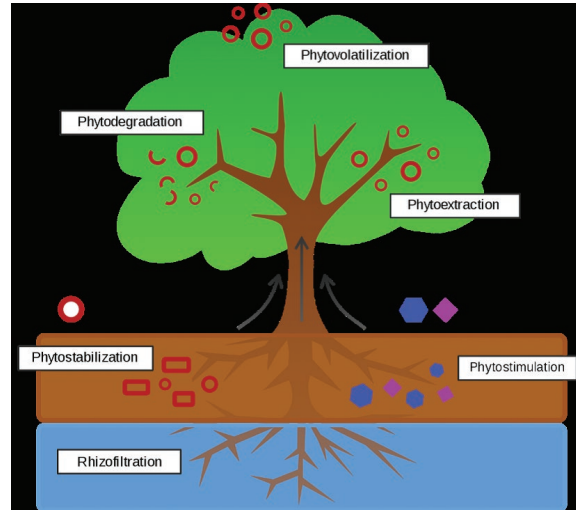
The remediation of heavy metals by environment-friendly technologies or approaches such as phytoremediation and vermiremediation is very effective and useful.

1.1. Phytoremediation

Phytoremediation is the utilization of green plants and microorganisms to remove contaminants from the environment [4]. Phytoremediation is an energy efficient, cost-effective method of remediation of heavy metals with low-to-moderate levels of contamination. This technique becomes more effective, as modified plants are used for remediation [4]. Phytoremediation technology can be subdivided, on the basis of its underlying processes and applicability, as follows: see (Figure 1) [4].

Phytoremediation of heavy metals is an emerging technology that includes techniques such as phytoextraction, rhizofiltration, phytostabilization, and plant-assisted bioremediation, in which plant roots in conjunction with its rhizospheric microorganisms are used to remediate soils contaminated with organics. Recent research work concluded that *Bacillus cereus* KTSMBNL 43 could be an effective, promising, and potential biosorbent for the removal of Cd²⁺ from aqueous solution because of its considerable biosorption capacity, environment-friendly nature, and low cost [5]. Biosorptive removal of Zn(II) ions by *Pongamia* oil cake (*Pongamia pinnata*) in batch and fixed-bed column studies showed that pH and temperature are significant factors for the removal of Zn(II) in batch mode and metal ions concentration and bed height are significant factors in continuous mode [6]. Several bacterial strains are isolated and characterized for metal removal or reduction. The bacterial strain *Cellulosimicrobium funkei* AR8 has high Cr(VI) reduction capacity [7,8], and *Ralstonia solanacearum* KTSMBNL 13 is a promising candidate to remove lead [9].

Figure 1: Techniques involved in bioremediation/ phytoremediation/ rhizoremediation [4].



Phytoextraction: Uptake of pollutants from environment and its concentration in harvestable plant biomass.

Phytostabilization: Reduction of mobility and bioavailability of pollutants in the environment.

Rhizofiltration: Use of plant roots to absorb and adsorb pollutants or nutrients from water and wastewater (e.g., buffer strips).

Phytovolatilization: Removal of pollutants from soil or water and their release into air as less-polluting substances.

Phytodegradation: Chemical modifications of pollutants because of plant metabolism, both in planta and in explanta, often resulting in its invasion, degradation (phytodegradation), or immobilization (phytostabilization)

Phytostimulation: Also referred to as enhanced rhizosphere biodegradation, rhizodegradation, or plant-assisted bioremediation/degradation via enhanced microbial activity in the plant root zone or rhizosphere.

Several advantages of using phytoremediation are given below:

- Amendable to a variety of organic and inorganic compounds [10].
- *In situ/ex situ* application possible with effluent/soil substrate, respectively [10].
- *In situ* applications decrease the amount of soil disturbance compared to conventional methods [11].
- Does not require expensive equipment or highly specialized personnel [12].
- Low cost and environment-friendly method [13].

Several reports show the success story of phytoremediation by using different plants [14-16]

1.2. Vermiremediation

Vermiremediation is the process of remediation of soil (heavy metals, soil fertility) or stopping environmental damage by the implementation of earthworms. Vermiremediation is an environment-friendly process. Earthworms produce vermicompost from organic materials that act as a conditioner to soil. It reduces the contaminants in organic wastes that lead to soil toxicity. Different species of earthworms are used in vermiremediation: the most common types of earthworms used for vermicomposting are brandling worms (*Eisenia foetida*) and red worms or red wigglers (*Lumbricus rubellus*) [17].

The macro- and micronutrients present in vermicompost and traditional compost are compared in Table 1.

Several advantages of using vermicompost/vermiremediation are given below:

- Better productivity and growth of plants [19].
- Vermicompost contains high levels of soil enzymes and plant growth hormones [20]. It increases the root, shoot, and weight, stimulates plant growth, and makes the soil pathogen-free as compared to a traditional compost used [21, 22].
- Also effective in remediation of contamination caused by petroleum products [23].

Many other researchers have reported the effective and significant results by use of vermiremediation techniques [24-26].

Table 1: Nutrient content of vermicompost (weight in mg/kg) and traditional compost [18].

Nutrient content	Vermicompost	Traditional compost
Fea	590.04 ± 1.52	620.04 ± 1.60
Cua	9.03 ± 0.20	8.04 ± 0.23
Zna	11.54 ± 0.37	9.85 ± 0.37
pH	8.92 ± 0.09	8.40 ± 0.10
TKN (%)	2.40 ± 1.20	1.03 ± 0.24
TOC (%)	37.12 ± 0.11	45.40 ± 1.01
EC (mS/cm)	2.82 ± 0.03	3.22 ± 0.02
C:N ratio	15.46 ± 0.57	44.30 ± 1.62
TNa (%)	1.41 ± 0.38	0.71 ± 0.20
TAP (%)	1.49 ± 0.81	0.92 ± 0.30
TK (%)	1.90 ± 2.08	4.01 ± 1.20
Mna	38.01 ± 0.88	13.02 ± 1.77

2. CONCLUSION

As pollution is increasing day by day due to anthropogenic reasons, toxicity of heavy metals is a big concern to researchers. Phytoremediation and vermiremediation are very useful and environment-friendly techniques for removal of heavy metal toxicity, and these techniques also improve the soil fertility. In this manner, these eco-approaches are simple, cost effective, and very significant for saving the environment. Research work is further needed to improve such eco-friendly techniques that are roots to sustainable development.

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Author Contributions

All authors contributed equally to this article.

Conflict of Interest

There is no conflict of interest.

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